Traffic- Related Air Pollution:
A Critical Review of the Literature on Emissions, Exposure, and Health Effects

13th ETH Conference on
Combustion Generated Nanoparticles
June 23, 2009

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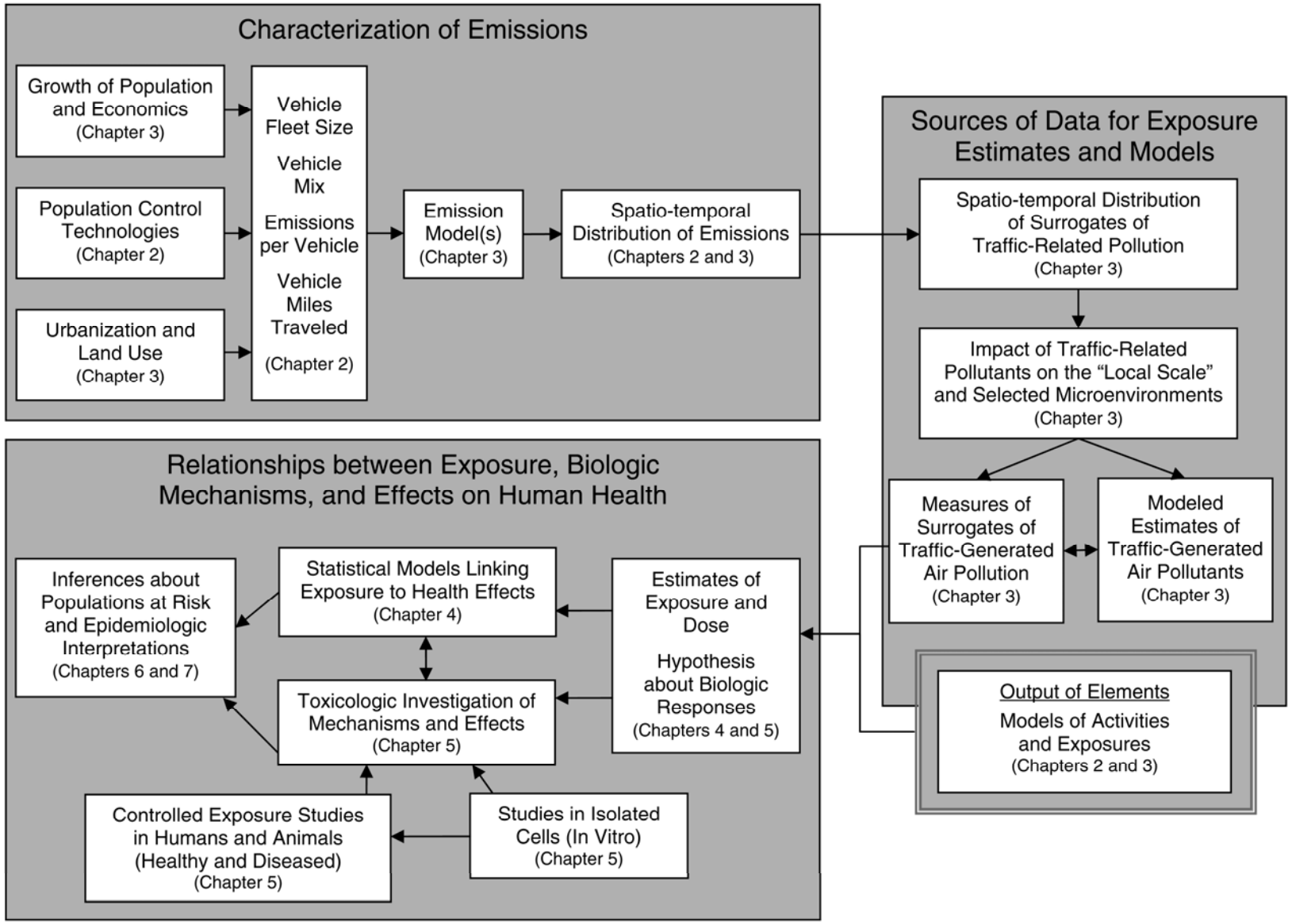
Goals of the Review

Summarize and synthesize relevant information on air pollution from traffic and its health effects linking

- Information on tailpipe emissions with human exposure
- Human exposure to air pollution from traffic with human health effects (epidemiology)
- Toxicological data with epidemiologic associations

A preprint of the report was released in May 2009
The formal Report will be published in the fall of 2009

Scheme of Report Organization



Organization of the Panel

- Emissions and Exposure Characterization
  - Kenneth Demerjian* (chair), Michael Jerrett, Brian Leaderer *, Fred Lurmann, Mike Walsh
- Epidemiology
  - Ira Tager (chair)*, Nino Künzli, Thomas Lumley, Sylvia Richardson*, John Samet
- Toxicology
  - Mark Frampton (chair), Frank Kelly, Lester Kobzik

*Member of Research or Review Committee

Emissions from Motor Vehicles
The Current Context

Significant progress has been made in reduction of pollutant emissions from motor vehicles despite increases in number of vehicles and vehicle miles traveled

Increased urbanization and urban populations have:

- Increased dependence on motor vehicles and traffic congestion
- Changed land use patterns such that **more people are near traffic sources of pollution**

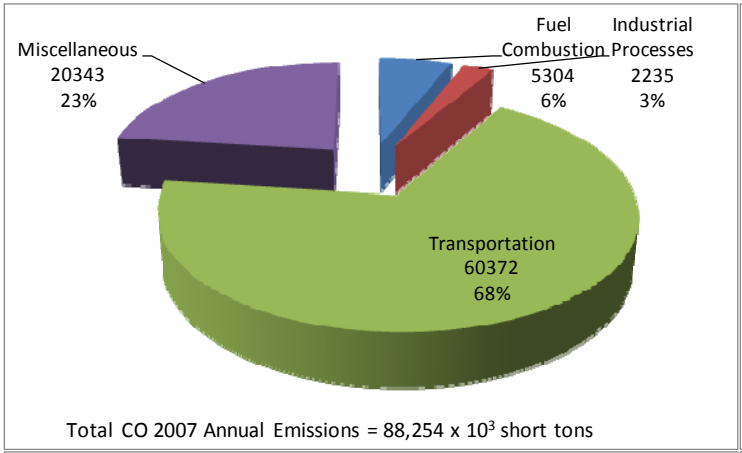
Emissions from Motor Vehicles

Premise: Emissions data are needed to:

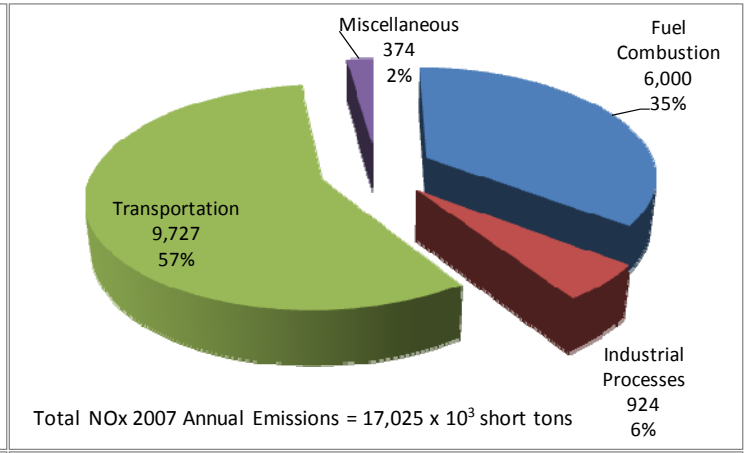
- Describe exposure
  - Trends in transportation emissions in the context of national inventories
    - Effects of control technologies, new fuels, etc
  - Emissions inventories and modeling
  - Physical and chemical transformations near roads

- *Understand the relative importance of traffic emissions to air pollution in total and at specific locations*
  - Contribution to PM, gases, VOC, NO_x

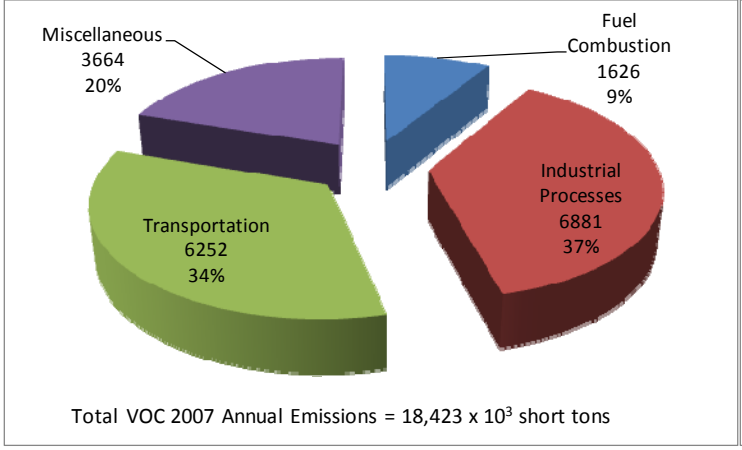
Annual 2007 CO, NOx,VOC, and SO2 Emissions Distribution in the US



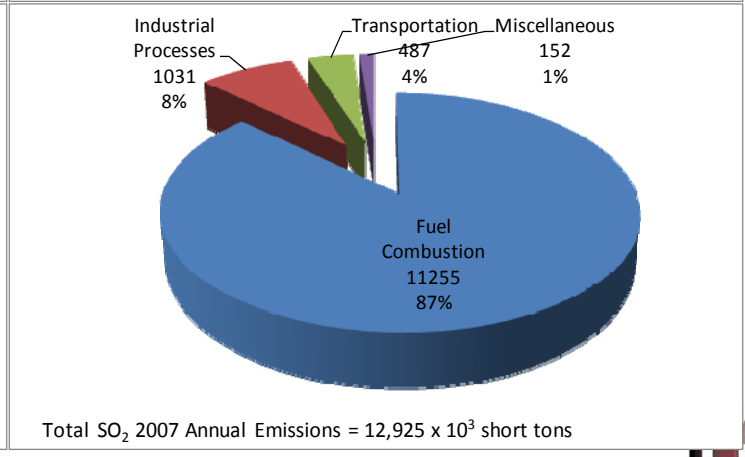
Total CO 2007 Annual Emissions = 88,254 x 10^3 short tons



Total NOx 2007 Annual Emissions = 17,025 x 10^3 short tons



Total VOC 2007 Annual Emissions = 18,423 x 10^3 short tons

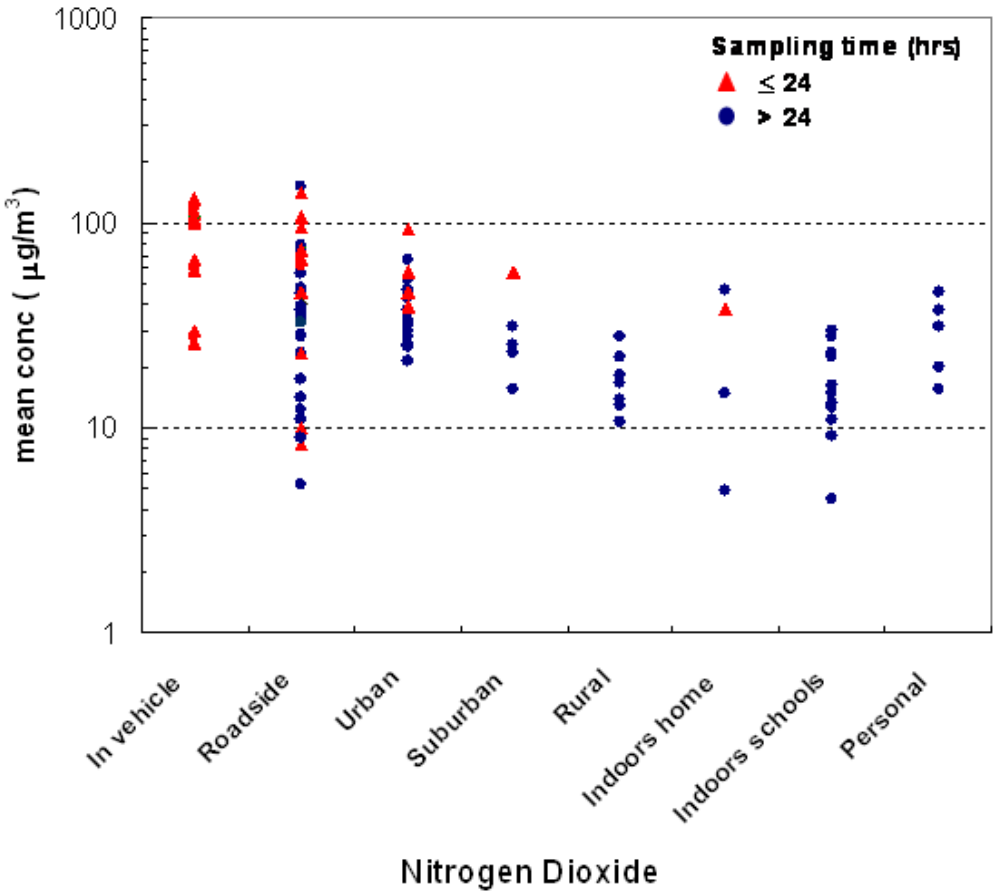


Total SO_2 2007 Annual Emissions = 12,925 x 10^3 short tons

Exposure to Primary Traffic-Generated Air Pollution (PTGP)

- **Exposure surrogates used in epidemiologic studies**
  - Pollutant surrogates for traffic exposures (e.g., NO_2, EC/BS, CO, UFPM, benzene, etc.)
  - Distance from and/or length of roadways
  - Estimate of traffic density or intensity
  - Modeling of primary traffic-generated pollutant exposure

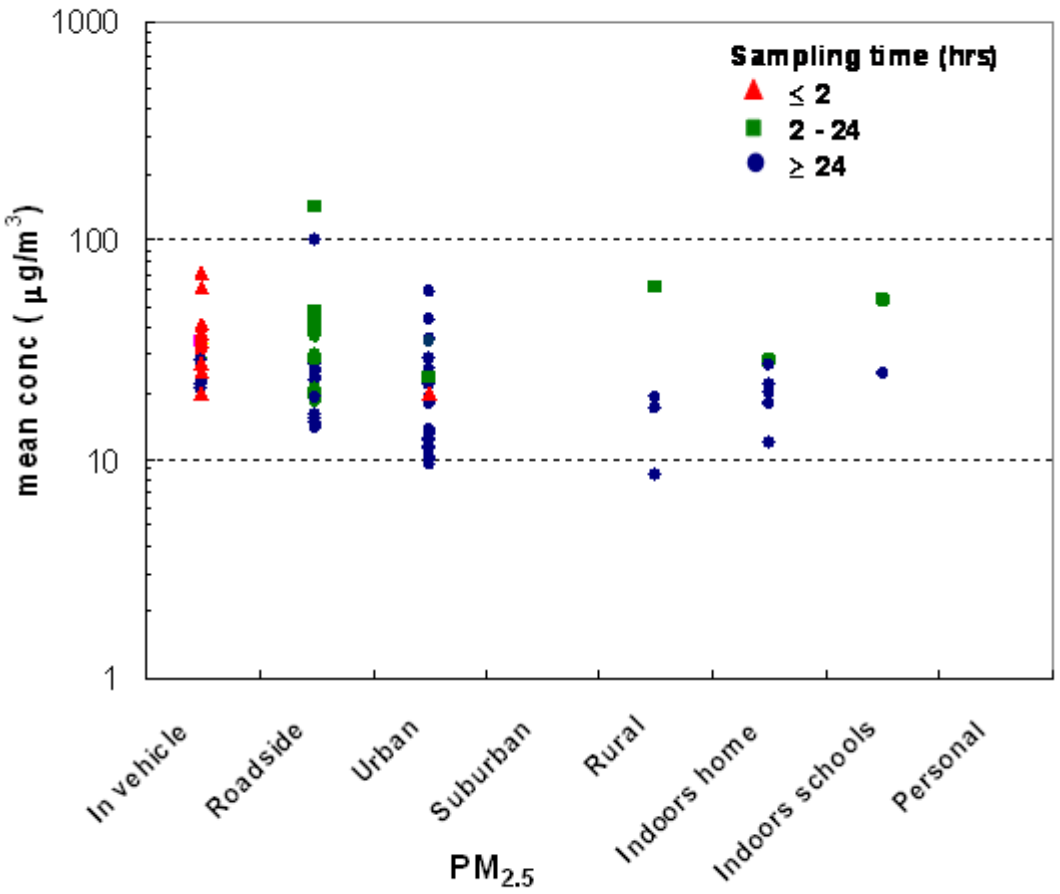
NO_2 Measurements



- There is substantial variability in average concentrations by locations.

- NO2 is a potential surrogate for vehicle emissions if it is measured on a fine spatial resolution.

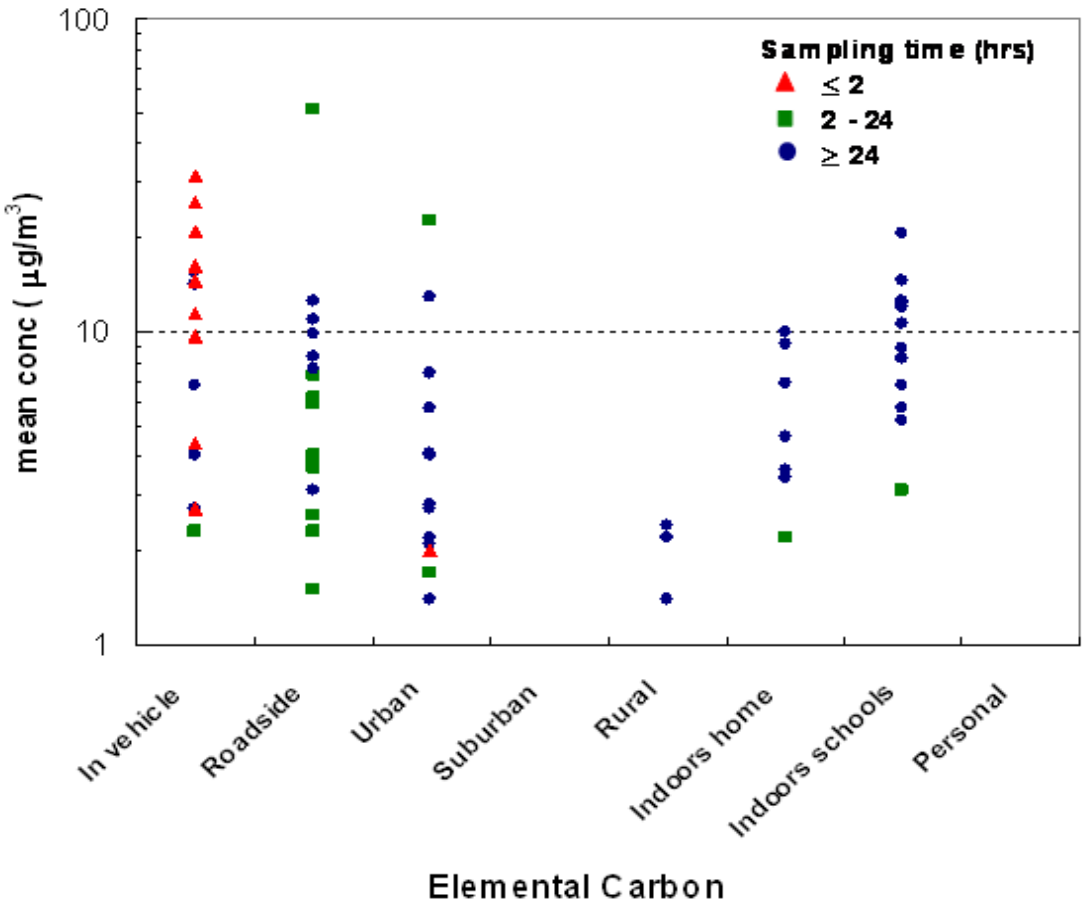
$PM_{2.5}$ Measurements



- Use of $PM_{2.5}$ as a surrogate is of limited value because many sources contribute to urban PM2.5 and $PM_{2.5}$ concentrations are well mixed within a region

- Current central monitors do not provide sufficient spatial resolution for assessing the contribution of traffic to ambient $PM_{2.5}$

Elemental Carbon Measurements



- Data suggest that EC is highly variable in ambient air.
- Its contribution from traffic needs to be evaluated against other anthropogenic emissions

Exposure Models

Models used

- Proximity models
- Geostatistical interpolation models
- Dispersion models
- Land-use regression models
- Hybrid models
  - Combine a model with time-activity data, or personal/microenvironmental monitoring

Epidemiology
Criteria for Causal Inference

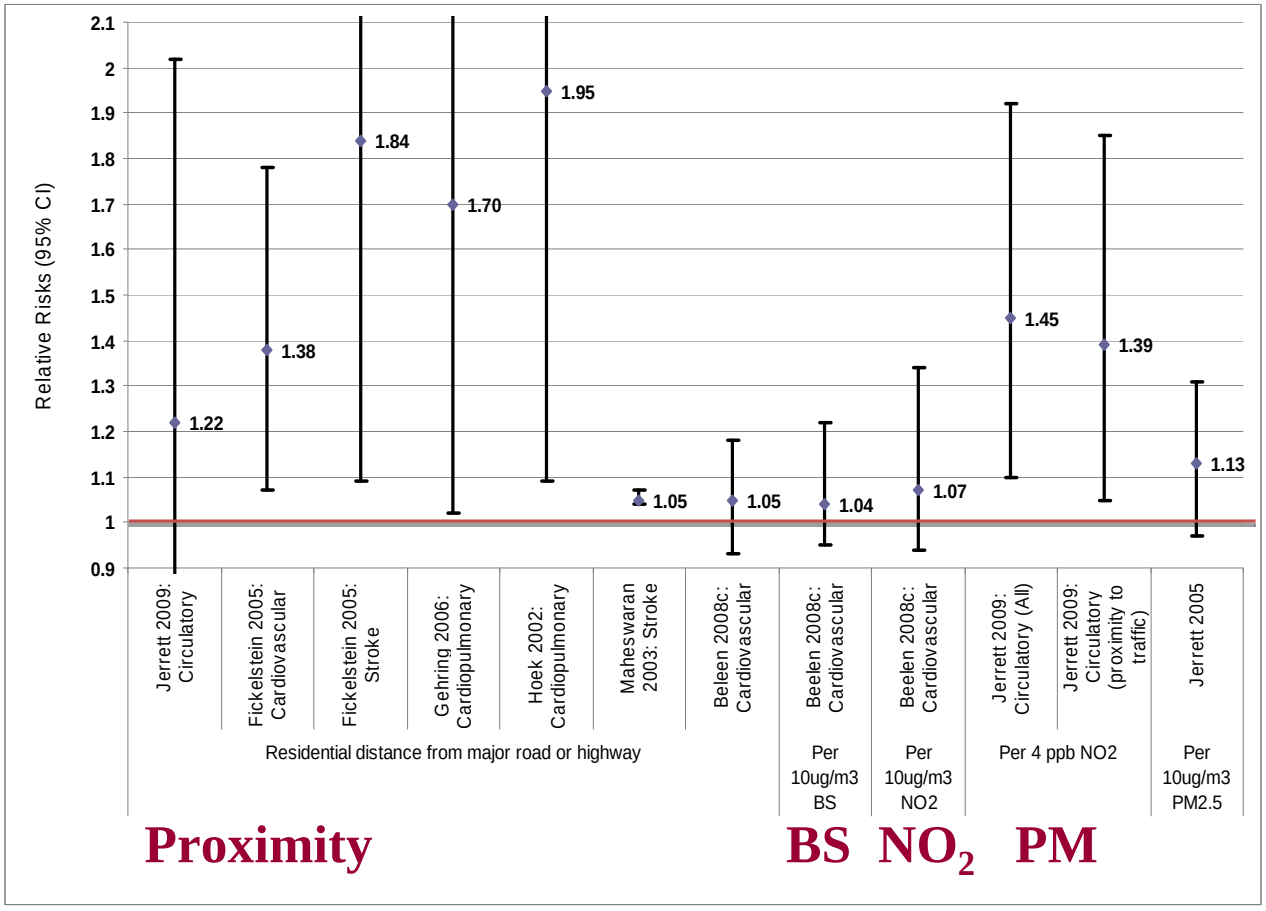
4 categories used to infer causal association based on how well studies controlled for confounding, on the consistency of the findings with other studies, and on the quality of the method to estimate exposure to primary traffic-generated pollutants

- Sufficient evidence
- Suggestive but not sufficient
- Inadequate and insufficient evidence
- Suggestive of no association

Epidemiology
Health Outcomes Evaluated

- Mortality (all cause, cardiopulmonary)
- Cardiovascular morbidity
- Respiratory disease
  - Asthma—childhood/adult
  - General respiratory symptoms
  - Lung function-childhood/adult/COPD
  - Health care utilization
- Non-asthmatic allergy
- Birth Outcomes
- Cancer

Long-Term Traffic Exposure and Cardiopulmonary Mortality



Synthesis of Evidence

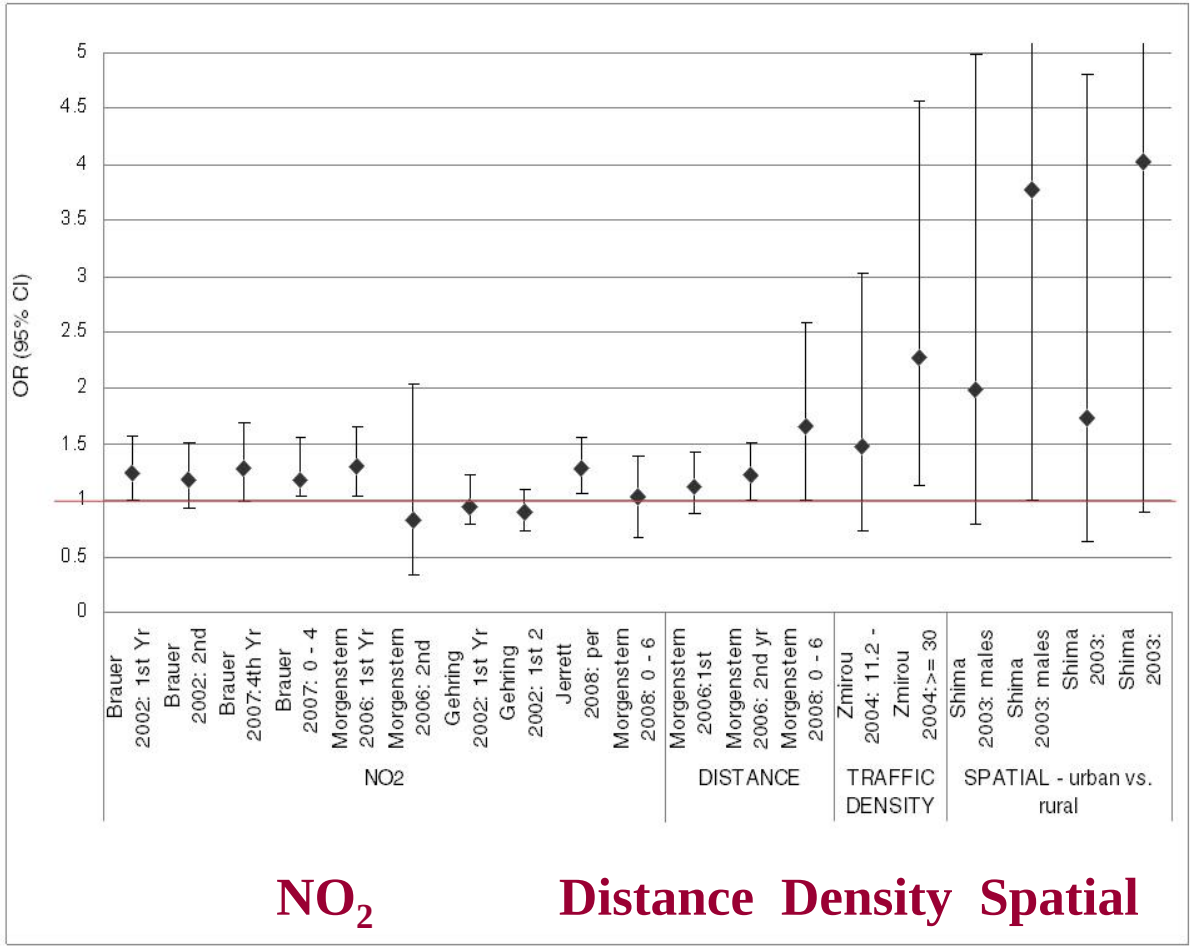
Suggestive but insufficient" to infer causal association

Reasons

Too few studies

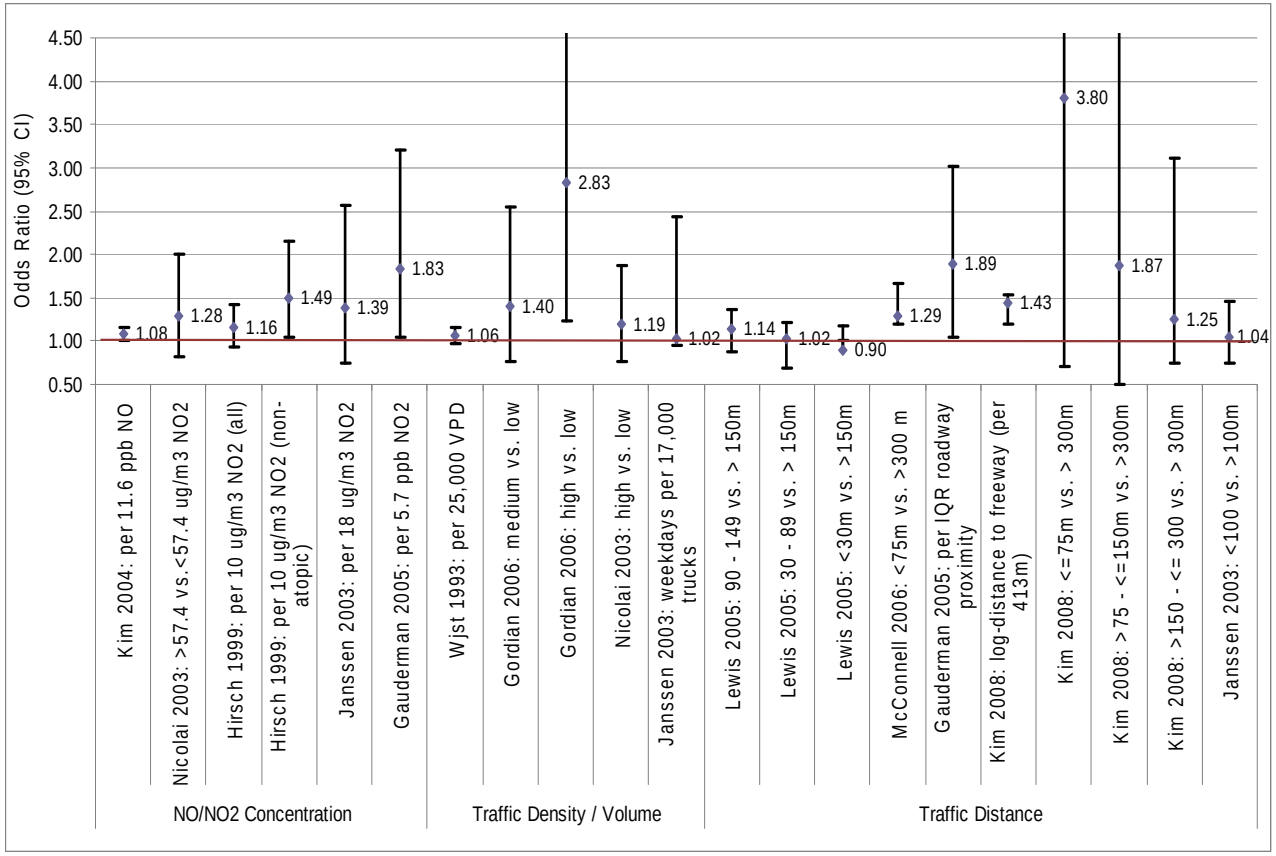
Relative imprecision of most estimates

Traffic Exposure and Asthma Incidence



NO_2 Distance Density Spatial

Traffic Exposure and Asthma Prevalence



Synthesis of Evidence

"Sufficient" OR "suggestive but insufficient" to infer causal association

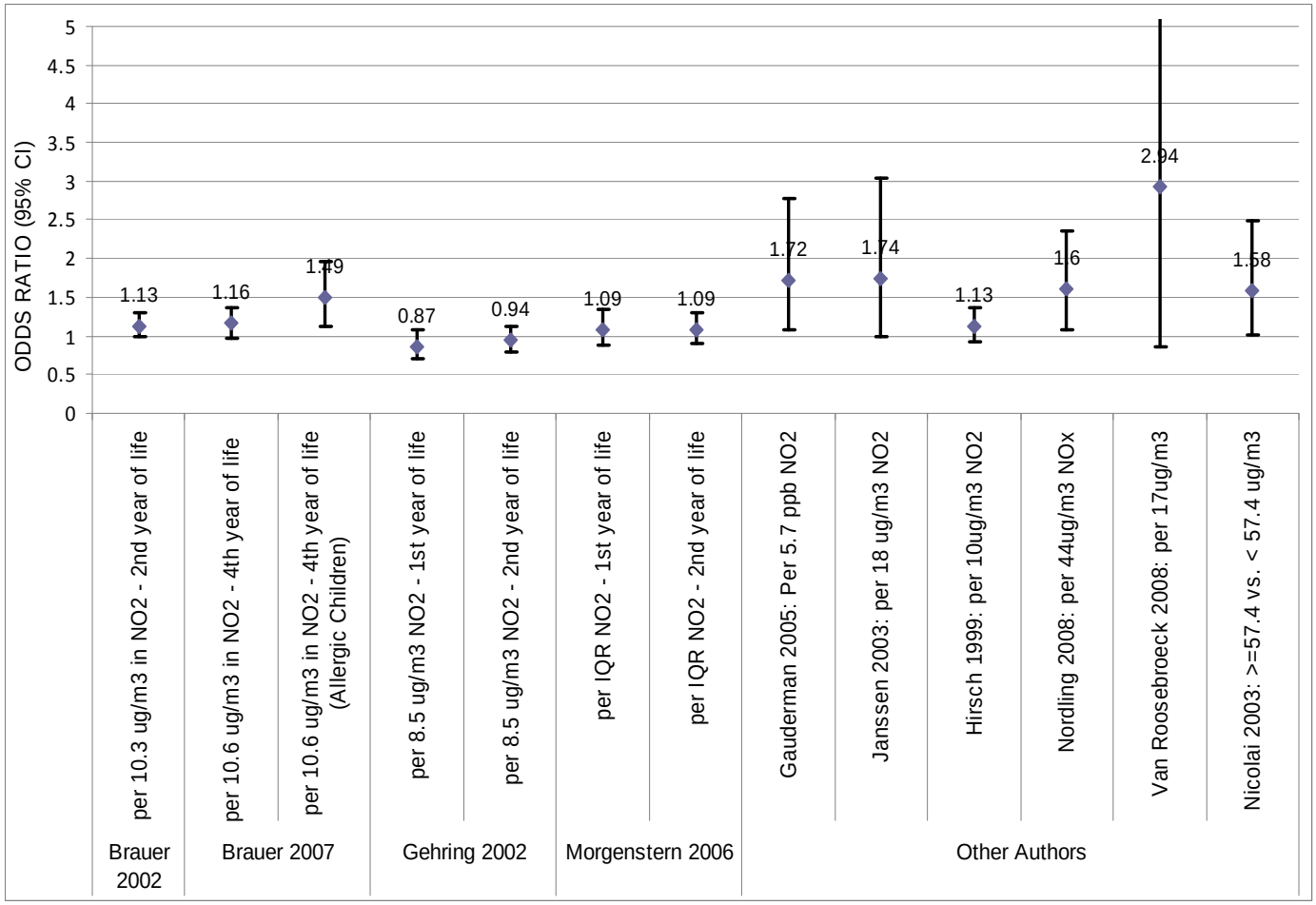
Reasons

Studies that included both traffic-specific pollutants and density measures most consistent

NO2 **Density/Volume** **Distance**

Exacerbation of Asthma Symptoms

Increase in Wheeze Per Increment NO2



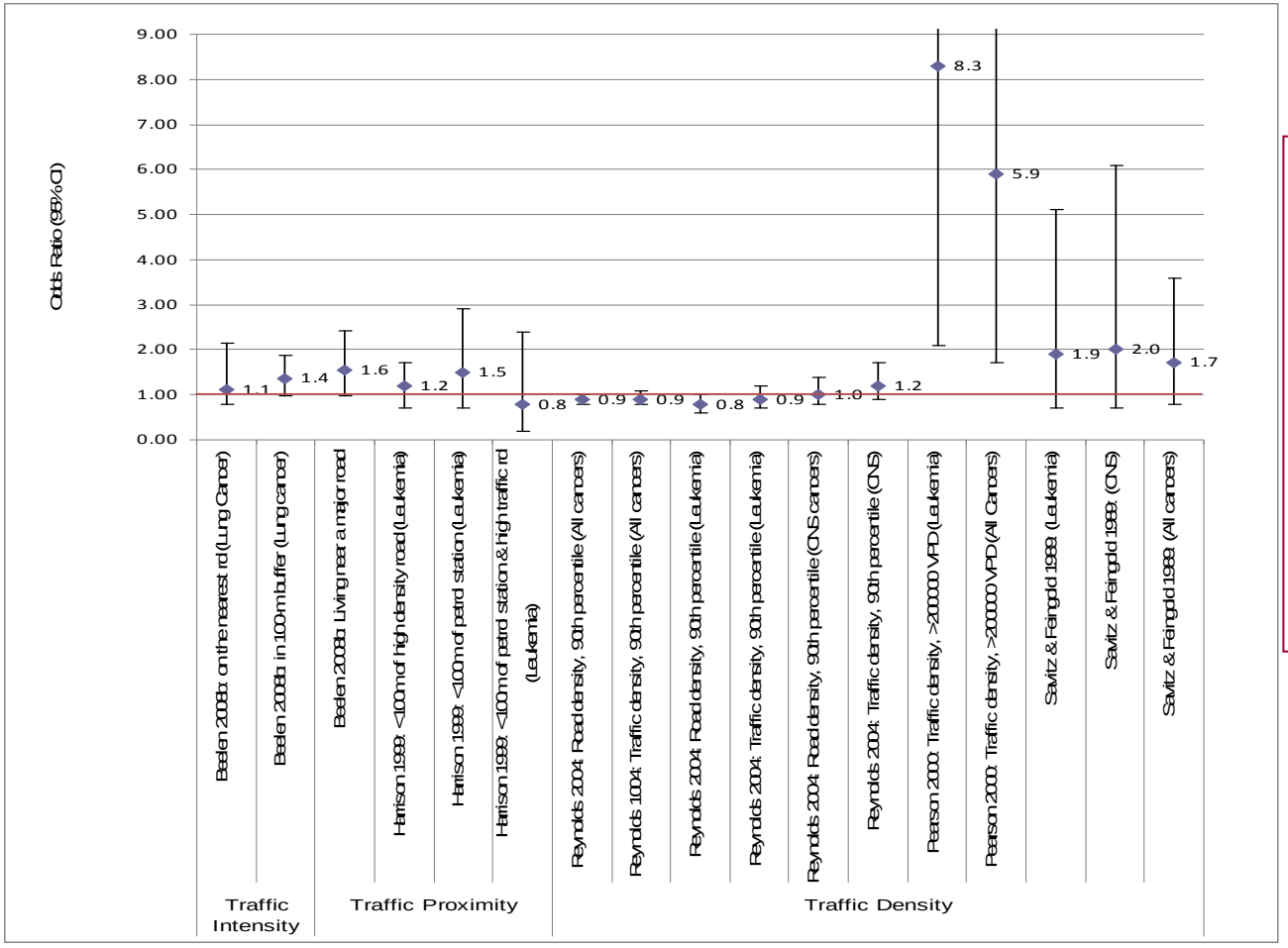
Synthesis of Evidence

Exacerbations with asthma—"Sufficient" to infer causal association

Reasons

Large number of studies with adequate control for confounding and mostly precise effect estimates

Traffic Exposure and Cancer



Synthesis of Evidence

"Insufficient" evidence to infer causal association

Reasons

Too few studies of any one type of cancer

Conclusions

Exposure to Primary Traffic-Generated Air Pollution

- Traffic-related pollutants impact ambient air quality on a broad spatial scale ranging from roadside, to urban, to regional background

- Based on synthesis of evidence, 500 meters from major road was identified as the near-source area most impacted by traffic; variations exist depending on meteorology, background pollution, and local factors

Issues for Exposure to Primary Traffic-Generated Air Pollution

- None of the pollutant surrogates considered met all criteria for an ideal surrogate
  - CO, benzene, and NOx [NO_2] found in on-road vehicle emissions are major components of emissions from all sources
  - UFPM have not been used in epidemiologic studies so far. It is difficult to model them because there are no emission inventories
- Exposure models are important, but have various degrees of utility to health studies
  - The proximity model is the most error-prone
  - The hybrid model provides a feasible “best” estimate of exposure

Conclusions From Epidemiologic Studies

- "Sufficient " evidence to Infer causal associations
  - Exacerbations of asthma
  - *Asthma incidence and prevalence in children*
- "Suggestive but insufficient" evidence
  - Mortality (all-cause and cardiovascular)
  - Decreases in lung function
  - General respiratory symptoms
- "Inadequate and insufficient" evidence to Infer causal associations
  - Adult onset asthma
  - Health care utilization for childhood and adult respiratory diseases
  - COPD
  - Non-asthmatic allergy
  - Birth outcomes
  - Cancers

Summary

Epidemiology studies are based on past estimates of exposure and they may not provide an accurate guide to estimating health associations in the future

Given the large number of people living within 300- 500 meters of a major road, the Panel concluded that exposures to primary traffic generated pollutants are likely to be of public health concern and deserve attention

For a preprint version visit ww.healtheffects.org